3690-Pos Board B551
Direct Electron-Beam Nanopatterning of Teflon AF Surfaces for Site-Selective Formation of Molecular Phospholipid Films
Mehrnaz Shaali, Samuel Lara Avida, Sergey Kubatkin, Aldo Jesorka.
Chalmers University of Technology, Gothenburg, Sweden.
Teflon AF is a family of amorphous copolymers containing fluoroethylene and dioxole groups. Its splendid properties such as low surface energy, high optical transmission, chemical resistance and low autofluorescence, have made it a desirable surface for the fast generation of molecular phospholipid films, which are being evaluated for biosensing and single molecule spectroscopy. The possibility of confinement of chemical species to a surface-adhered 2-dimesional film, while keeping them mobile within the structure, circumvents many problems of volume-based flow systems (Czolkos et al. 2011). Patterning the Teflon AF by common photolithography is limited to a few specialized processes with micrometer resolution, and it is still difficult to get nano-structured Teflon AF surfaces. It has been shown that a thin film of Teflon AF can be directly patterned by electron beam lithography without the need of further chemical development (Karre et al., 2009), where degradation of the fluorinated dioxole groups by electron beam radiation changes the hydrophobicity of the exposed area.We have established that electron beam-exposed Teflon AF features far lower hydrophobicity, effectively preventing the spreading of phospholipid monolayers. By taking advantage of this functional difference, we established a nanostructuring protocol by means of electron beam frame exposure around a desired nano-scale region. The frame exposure outlines desired surface areas of high hydrophobicity by a region of low hydrophobicity, confining the lipids in the framed surface areas. The method represents an effective nanopatterning strategy for a specialized surface application, the controlled formation of self-assembled molecularly thin films, which we are developing into a new platform for single molecule studies.

3691-Pos Board B552
Electronics Configuration to Co-Trap Single DNA Molecules in Dual Solid-State Nanopores - Solving the DNA Translocation Rate Problem
Jungsuk Kim, Shea Ellerson, **William Dunbar**.
UCSC, Santa Cruz, CA, USA.
Nanopore sequencing aims to identify DNA bases by detecting base-specific signatures in the nanopore current signal, which are generated in principle when a DNA molecule passes through the nanopore channel. Nanopore channels can be formed by employing a protein channel in a lipid membrane, or by fabricating a ''solid-state'' pore in a substrate such as silicon nitride. Among several obstacles for nanopore sequencing, one challenge is that the DNA passes too quickly through the nanopore. One conventional solution is to reduce the command voltage, which is related to the intensity of the electric field. However, the decreased voltage leads to a reduction in the measured current, resulting in a loss in signal-to-noise ratio (SNR). We present a novel dual-nanopore concept that can permit high SNR while simultaneously controlling the DNA's speed through the nanopores. The configuration achieves this by electrophoretically trapping DNA between the two pores. The primary element of the proposed dual-nanopore architecture is an electrical configuration to independently control the voltage across each nanopore and simultaneously sense variations in each nanopore current signal. In the implementation presented, the dual-nanopore channels are fabricated in silicon-nitride membranes where the pores are serially and concentrically aligned within 0.4μm. We implement a pair of fully integrated low-noise CMOS patch-clamp amplifiers developed in our lab for independent and simultaneous voltage control/current measurement in the dual-nanopore device. Finite state machine logic running on a field-programmable gate array (FPGA) controls each amplifier and logs data. We will present our preliminary results on capturing a single DNA in both pores, and controlling the DNA's motion by competing voltage control.

3692-Pos Board B553
Single-Molecule Kinetics and Thermodynamics Analysis of DNA-Bound Crown Ether/Cation Interactions within the Alpha-Hemolysin Ion Channel
Na An, Aaron M. Fleming, Henry S. White, Cynthia J. Burrows.
University of Utah, Salt Lake City, UT, USA.
The α-hemolysin (α-HL) protein ion channel has been under intensive investigation as a single-molecule DNA analysis platform.[1] Recognizing the fast speed at which single-stranded DNA (ssDNA) is driven through the channel electrophoretically, we have explored site-specific attachment of adducts to DNA bases as a promising approach to advance this technology by producing unique current signatures and reducing the speed of DNA translocation to a level appropriate for modern electronics.[2] The ability of crown ethers to selectively complex various cations has been extensively utilized to improve the development of molecular switches, sensors, biomedical agents and biological model systems in the past five decades.[3] Herein, by selectively functionalizing DNA with crown ethers, we demonstrate a real-time analysis strategy for crown ether/cation interactions within the α-HL ion channel to establish the association/disassociation rates and the equilibrium constants at a single-molecule level. Additionally, it provides a tunable and universal label for individual DNA identification by selecting the composition of the electrolyte. This approach should be beneficial to both DNA damage detection and sequencing efforts.
Reference
1. Branton D.; et al. The potential and challenges of nanopore sequencing. *Nat. Biotechnol.* **2008**, 26, 1146-1153.
2. Schibel, A. E. P.; An, N.; Jin, Q.; Fleming, A. M.; Burrows, C. J.; White, H. S. Nanopore detection of 8-oxo-7,8-dihydro-2'-deoxyguanosine in immobilized single-stranded DNA via adduct formation to the DNA damage site. *J. Am. Chem. Soc.* **2010**, 132, 17992-17995.
3. Gokel, G. W.; Leevy, W. M.; Weber, M. E. Crown ethers: sensors for ions and molecular scaffolds for materials and biological models. *Chem. Rev.* **2004**, 104, 2723-2750.

3693-Pos Board B554
Translocating Single-Stranded DNA through Crystalline Graphene Nanopores
Gregory F. Schneider, Qiang Xu, Bo Song, Stephanie Luik,
Stefan Kowalczyk, Victor Calado, Meng Yue Wu, Gregory Pandraud,
Sairam Maldi, Henny Zandbergen, Cees Dekker.
TU Delft, Delft, Netherlands.
Here, we report the successful translocation of single-stranded DNA through graphene nanopores which normally is plagued by sticking of the bases on the graphene, which we have now solved (we will reveal the details of this crucial issue at the BPS meeting). We recently developed a simple and fast water-based method for transferring graphene onto arbitrary surfaces, with micrometer alignment precision. Using this method, we fabricated ranges of graphene membranes in which nanometer sized pores were sculpted. Under an electron beam, we discovered that graphene undergoes a temperature sensitive self-repair mechanism that allows damage-free atomic scale sculpting of perfectly crystalline graphene nanostructures, such as nanopores with crystalline edges. When mounted between two flow chambers containing buffered DNA, these extremely thin nanopores were used to detect DNA molecules and very recently single-stranded strands of DNA. As individual DNA molecules translocate through the pore, characteristic temporary conductance changes were observed in the ionic current through the nanopore, setting the stage for future single-molecule genomic screening devices.

3694-Pos Board B555
Simulating Nanopore Sensor Dynamics Over Long Times Scales
Daniel L. Burden[1], Bryon Drown[1], Michael J. Culbertson[1],
Joseph E. Reiner[2], Joseph W.F. Robertson[3], Arvind Balijepalli[3],
John J. Kasianowicz[3].
[1]Wheaton College, Wheaton, IL, USA, [2]Virginia Commonwealth University, Richmond, VA, USA, [3]National Institute of Standards and Technology, Gaithersburg, MD, USA.
Nanopores of both synthetic and biological origin hold broad potential for single-molecule sensing applications. We present a Brownian kinetic model that combines: (1) analyte diffusion kinetics; (2) electrophoretic drift; (3) and convective electroosmotic flow. This approach provides insight into analyte behavior over relatively long time scales (microsecond to millisecond).
The simulation utilizes a distributed computer network to model these three kinetic factors in beta-cyclodextrin (βCD)-modified αHL. The structure of this modified channel is simplified to a three-dimensional reflecting solid, whereby diffusing analytes are individually tracked as they migrate above the pore and through the lumen. Based on measurements of diffusion constants, electrophoretic mobility, and electroosmotic flow rates through the nanopore, the simulator follows trajectories of particles located at different positions relative to the mouth of the pore. We present data collected over a range of applied transmembrane potentials and estimate the probability of capturing analytes as a function of distance relative to the pore. The timing of analyte arrival at the βCD detection site is also described. The results highlight the dominance of thermal diffusion and illustrate the relative contribution of each of the three kinetic factors in the production of detection events.